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A PRELIMINARY REPORT ON THE OCCURRENCE OF WESTERN RED-ROT IN PINUS PONDEROSA.

By W. H. Long,
Forest Pathologist, Office of Investigations in Forest Pathology.

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INTRODUCTION.

In the national forests of Arizona and New Mexico a varying percentage of the trees of western yellow pine (*Pinus ponderosa*) is affected by an undescribed heart-rot, known locally as red-heart, red-rot, gray-rot, top-rot, and heart-rot. The amount of this rot present varies materially with the exposure, slope, and soil on which the yellow pine is growing, as well as with the age of the timber itself. It is the main heart-rot found in western yellow pine in Arizona and New Mexico and causes an annual loss of thousands of dollars.

This heart-rot is here called "western red-rot" in order to distinguish it from the true red-heart or red-rot, a very similar heart-rot common in many species of conifers throughout the world. True red-rot or ring scale is caused by *Trametes pini*, while western red-rot is produced by an entirely different fungus.

DESCRIPTION OF WESTERN RED-ROT.

CROSS-SECTIONAL VIEW.

Western red-rot may show in the end of a freshly cut log any one of the following stages: (1) An early stage, in which the heartwood is firm but shows reddish to dark-brown discolored areas. Such

areas are often fan shaped and radiate outward from the center of the log, like spokes from the hub of a wagon wheel, or they may be isolated and occur anywhere in the heartwood. (2) A more advanced, or what might be called an intermediate stage, of the rot, in which the affected heartwood is whitish or grayish in color and is so disintegrated that small pieces can be pulled out. The rotted wood consists of soft white strands of cellulose, intermixed with less rotted wood particles. The rotten wood in this stage is often so wet and soggy that water can be squeezed out of it. The white-rot or gray-rot stage is usually in the center of the log and is often surrounded by the brownish fanlike areas seen in the first stage of the rot. (3) A third or final stage of the rot, in which much of the heartwood has been destroyed, leaving the remainder in a very brittle, rotten condition, so that it easily crumbles when handled. In this final stage of the rot all of the cellulose has been absorbed by the fungus, while the wood particles left are reddish to dark brown in color. This stage sometimes occupies only a small portion of the heartwood in the center of the log and may be surrounded by one or both of the other stages.

LONGITUDINAL-SECTION VIEW.

In a longitudinal section, as seen in sawed lumber, the different stages of the rot gradually merge into one another. In the place where the fungus entered the tree will be found the oldest stage which the rot has reached in that particular lesion. If the entire lesion originated from only one center of infection (one dead branch) and the rot has been in the tree for many years, then the three stages described will probably be represented in the one lesion, which may be anywhere from 12 to 20 feet long. There will usually be some 6 to 10 feet in the center of the log which belong to the second and third stages of the rot, while the extremities of the rot lesion will consist of the first stage of the rot.

DEVELOPMENT OF WESTERN RED-ROT IN THE TREE.

This rot advances nearly as rapidly radially as it does longitudinally in the heartwood of the affected tree. Its radial development in the wood is rather peculiar. From the central cylinder of the rot, at irregular intervals along its entire length, narrow radial patches of rot extend outward toward the sapwood. These radial patches are the fanlike or spokelike discolored areas on the end of the log, described under the first stage of the rot. The centers of these radial patches usually consist of whitish delignified tissue, bordered by reddish to dark-brown areas of heartwood which have not yet been delignified but are in the early stages of the rot. Often some of the cellulose in the center of these patches has been entirely absorbed, leaving small irregular cavities extending to the sapwood.

From these radial patches the rot spreads in all directions, until finally the entire heartwood is involved. In tangential sections these radial patches of rot appear as irregular elliptical reddish to brown areas with white centers. These areas are two to several times longer than broad, with their greatest diameter lying parallel with the grain of the wood. There is often a small cavity bordered by the unabsorbed remnants of the delignified tissue in the center of each rotted area. Usually two to six of these discolored areas are grouped together, giving the sawed lumber a very peculiar appearance.

COMPARISON OF WESTERN RED-ROT AND TRUE RED-ROT.

When examining the rot in the end of a freshly cut pine log it is often difficult to determine whether it is western red-rot or true red-rot. A longitudinal view of the rot, however, usually will settle the question beyond any reasonable doubt, since the following constant characters are then in evidence: (1) True red-rot, or red-heart, caused by *Trametes pini*, has many small but sharply defined pockets, or cavities, in the heartwood, lying parallel to the grain of the wood, while western red-rot never has these typical pockets. (2) The attacked wood in true red-rot is usually very firm, even in the final stage of the rot, while western red-rot in its last stage is much disintegrated and easily crumbles when handled. (3) The mycelium of true red-rot when growing in heartwood which is more or less exposed to the air is brown, while the mycelium of the western red-rot is always white. (4) The attacked heartwood in true red-rot never becomes wet and soggy, as it often does in certain stages of western red-rot.

CAUSE OF WESTERN RED-ROT.

The fungus which causes western red-rot never forms brown, woody, perennial fruiting bodies on the boles of living affected pine trees, as *Trametes pini* does, but forms annual fruiting bodies, which are usually developed as white encrusting layers on the under side of logs lying on the ground. This fungus is also the main agent in rotting the sapwood of the cull logs and large branches of the yellow-pine slash.[1]

The fruiting bodies, or sporophores, of this fungus, as they occur in Arizona and New Mexico, are usually resupinate, with a hymenial layer consisting of minute tubes or pores. However, fruiting bodies have been found which have distinct and well-formed pilei. The pileate form of the fungus resembles very closely *Polyporus ellisianus* (*Tyromyces ellisianus* of Murrill in North American Flora); the

[1] Long, W. H. A new aspect of brush disposal in Arizona and New Mexico. *In* Proc. Soc. Amer. Foresters, v. 10, no. 4, p. 383–398. 1915.

writer, however, does not wish to call it by this name until the investigations now under way as to its identity are completed.

Lloyd reports a specimen of the same fungus from the State of Washington, collected by J. M. Grant,[1] and refers it to *Polyporus ellisianus*. The writer (through the kindness of Mr. Lloyd) has been able to examine a portion of the collection from Washington, and it agrees in all essential characters with the fungus which causes western red-rot in Arizona and New Mexico. Concerning the host of the Washington specimen Lloyd writes, "There was no note with the specimen regarding its host, excepting that it grew on a pine of some kind."

A sporophore of what is apparently the western red-rot fungus has been examined from Idaho.

Von Schrenk[2] in 1903 published a figure of a heart-rot of living trees of *Pinus ponderosa* from the Black Hills Forest Reserve in South Dakota, which is typical of the second stage (cross-sectional view) of this rot as it occurs in yellow pine in New Mexico and Arizona. It is therefore highly probable that this fungus is widely distributed throughout the West, both as a saprophyte in slash and dead trees and as a heart-rot in living timber. The writer has examined a specimen of the same fungus collected in New Jersey on *Pinus* sp. and one of both fungus and rot from Vermont on *P. strobus*.

ENTRANCE OF WESTERN RED-ROT INTO LIVING TREES.

The western red-rot fungus enters the living tree through dead branches in the crown. It first attacks the sapwood of the dead branch; then the heartwood. It then travels down the sapwood and heartwood of the dead branch into the heartwood of the living tree. Once established in the tree, the fungus apparently continues to grow as long as the tree is alive, spreading in all directions, until often the heartwood of the entire bole of the tree, as well as that of the large branches, is invaded and rendered worthless for lumber.

EXTERNAL SIGNS OF WESTERN RED-ROT.

No external signs were found which would absolutely determine whether or not a given standing yellow-pine tree was defective. Trees having large dead branches intermixed with living limbs and ragged and unhealthy looking crowns were often attacked by western red-rot. Such defective trees were usually located on very thin soil on steep south or east slopes, where growth conditions were very poor. However, many trees which showed no recognizable external evidences of decay were found to have western red-rot when they were felled.

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[1] Lloyd, C. G. Mycological writings, v. 4, letter no. 60, p. 4. 1915.

[2] Schrenk, Hermann von. The "bluing" and the "red rot" of the western yellow pine, with special reference to the Black Hills forest reserve. U. S. Dept. Agr., Bur. Plant Indus. Bul. 36, p. 34, 40, pl. 14, fig. 2. 1903.

AREAS EXAMINED FOR WESTERN RED-ROT.

Before marking an area for cutting it should be determined whether the rotation is to be short, medium, or long. Often the amount and character of the defect present in the timber will be an important factor in determining what rotation is best for the area in question, especially in stands of virgin timber.

In order to throw some light on the presence of defects, especially western red-rot, in western yellow pine and its probable influence on the rotation period, studies were conducted on certain areas in the Santa Fe National Forest where both tie trees and saw timber were being cut. The main problem which demanded immediate attention was the relative amount of rot present in the black jack on these areas compared to that in the yellow pine. The special areas examined were located in Cienega, Ocho, Amole, Gallegos, and La Junta Canyons and on adjacent mesas, all of which are situated in the Cienega ranger district. The data given here were obtained mainly from Cienega, Ocho, and Amole Canyons on areas which had been cut for hewn ties. A small area near the Cienega ranger station on which both ties and saw timber had been cut was also examined for rot. The tie trees ranged from 10 to 16 inches, d. b. h., while those over these diameters were saw timber. These areas were especially suitable for a study of this character, since an unusually large percentage of the black jack (30 to 50 per cent) and nearly all of the yellow pine (85 to 100 per cent) were being cut.

There are two forms of western yellow pine called, respectively, black jack and yellow pine. Black jack is the form which this pine assumes before it reaches the age of 125 to 150 years.[1] During this period its bark is blackish to dark brown, with narrow furrows, while the yellow-pine form has lighter colored, widely furrowed bark.

NUMBER AND KIND OF TREES EXAMINED.

In the vicinity of the Cienega ranger station, 1,691 felled black jacks and 547 felled yellow-pine trees were examined for rot. In addition to this, all of the trees 4 inches, d. b. h., and over on a sample strip 1 chain wide and 140 chains long, located on the mesa between Ocho and Cienega Canyons, were tallied by the district marking board of the Forest Service, carefully examined, and any evidences of disease or defect noted. One hundred and twenty-four felled black jacks (10 to 16 inches, d. b. h.) and 16 felled yellow pines (12 to 16 inches, d. b. h.) had been cut for hewn ties on this sample strip.

Table I shows the number of sound and defective trees on each of the areas examined and in a general way the character of the

[1] Woolsey, T. S., jr. Western yellow pine in Arizona and New Mexico. U. S. Dept. Agr., Forest Serv. Bul. 101, 64 p., illus, 4 pl. 1911.

site on which the trees were located. The amount of butt-rot (probably caused by *Polyporus schweinitzii*) present on the areas examined was so small that it was not included in the table. This explains any apparent discrepancy between the sum of the sound and defective trees and the total number of trees listed in the table.

TABLE I.—*Data on sound and defective felled trees of black jack and yellow pine.*

Area.	Kind of timber.	Number of trees.	Sound trees.		Defective trees (western red-rot).		Remarks.
			Number.	Per cent.	Number.	Per cent.	
1	Black jack	210	206	98	4	1.9	Top of ridge; growth conditions fair, mainly black jack.
	Yellow pine	20	18	90	2	10	
2	Black jack	294	293	99.66	0	.....	Lower portion of southeast slopes and bed of canyon; growth conditions fair.
	Yellow pine	84	73	86.9	10	11.9	
3	Black jack	126	124	98.4	2	1.6	South and southeast slopes; thin soil; slopes steep, rocky; growth conditions poor.
	Yellow pine	132	87	65.9	40	30.3	
4	Black jack	206	193	93.7	9	4.3	South and east slopes; thin soil; slopes steep; growth conditions poor.
	Yellow pine	76	57	75	14	18.4	
5	Black jack	855	836	97.7	14	1.6	Mesas; soil good; growth conditions good.
	Yellow pine	235	223	94.9	8	3.4	
6	Black jack	124	123	99.2	0	.....	14-acre sample strip across mesa; growth conditions fair.
	Yellow pine	16	13	81.25	3	18.75	
1–6	Black jack	1,815	1,775	97.8	29	1.59	Total for all areas.
	Yellow pine	563	471	83.6	77	13.6	
	Both kinds	2,378	2,246	94.4	106	4.5	

DISCUSSION OF THE DATA PRESENTED IN TABLE I.

A study of Table I shows several interesting facts: (1) There is a marked difference in the percentage of black jack and of yellow pine affected by western red-rot. (2) The site seems to have a decided influence on the occurrence of this rot, especially in the yellow pine. (3) The variation in the percentage of western red-rot on the different areas shown in the table is due to several factors, the three most prominent ones being the relative proportion of black jack and yellow pine which had been cut on each area, the influence of the site on the growth of the trees, and the age of the timber. For instance, on area No. 3 the percentage of this rot in yellow pine is high, due apparently to unfavorable growth conditions and the age of the timber cut.

Table I should give a fairly accurate idea of the occurrence of western red-rot in black jack of merchantable size in this region, since 1,855 trees of this kind were examined over areas where 30 to 50 per cent of the black jack 11 inches, d. b. h., and over had been cut. As an indication of the amount of this rot present in the yellow pine, Table I is not so conclusive, since, with the exception of areas 3 and 4, all of the yellow pine shown in the table was of small diameter (12 to 18 inches, d. b. h.) and was cut for hewn ties only. This means that the percentage of trees showing western red-rot in the yellow pine on these areas will be greater than is shown in the table, except

areas 3 and 4. The older the trees are, the greater the amount of rot present, since such trees have had more opportunities for infection than younger trees. However, taking the area as a whole, probably 20 per cent of the yellow-pine trees (exclusive of black jacks) will show western red-rot in some portion of the bole. The areas shown in this table are mainly covered with black jacks intermixed with only a small number of yellow pines. For instance, in the sample strip, 1 chain wide and 140 chains long, 195 black jacks were marked for cutting and 1,270 left, a total of 1,465 black jacks 4 inches, d. b. h., and over, while 108 yellow pines were marked and 22 left. Of the 1,465 black jacks present on this area, there were 605 trees of merchantable size (10 inches, d. b. h., and over) to only 130 yellow pines. This means that on such areas the percentage of western red-rot in the merchantable timber will be small compared to similar areas where the proportion of yellow pine is greater than that of black jack.

WESTERN RED-ROT IN BLACK JACK AND YELLOW PINE.

The percentage of western red-rot in black jack for all the areas is very small, since only 29 trees out of 1,815 (1.59 per cent) showed this rot, while in yellow pine it was much greater, 77 trees out of 563 (13.6 per cent) being infected. Even then, this percentage is not high when compared with some other areas in Arizona and New Mexico. For instance, on certain sale areas on the Upper Pecos River, 70 to 95 per cent of the yellow-pine trees were attacked by western red-rot. Since this rot enters mainly through dead branches it is easily seen why fewer black jacks are attacked by it than yellow pines. The total percentage of trees attacked by western red-rot, both black jack and yellow pine, is only 4.5 per cent for all the areas shown in Table I.

Of the black jacks infected with western red-rot, nearly all were suppressed or grown under very unfavorable conditions. This indicates that all such trees should be marked for cutting when possible, not only on account of their susceptibility to this rot, but also because they will never make strong, thrifty trees. When the soil is deep and capable of producing vigorous growth in the trees, western red-rot is present only in a small degree unless the trees are very old and overmature. Such soil conditions are found on many of the mesas and near the bottoms of small canyons. There is always a marked increase in the amount of western red-rot in yellow pine growing on very steep slopes and on poor, thin soil.

WESTERN RED-ROT AND THE ROTATION FOR WESTERN YELLOW PINE.

As to the relative efficiency of a long rotation and of a medium or short rotation period in finally eliminating this rot from the forest, the answer is very evident, judging from the viewpoint of the rot

alone. Table I clearly shows that during the black-jack period the trees are practically free from this rot, but as they grow older the increasing number of dead branches makes them more open to the attacks of this fungus; that is, after the trees enter the yellow-pine stage of their growth they are more and more subject to infection by heart-rotting fungi.

In the Cienega ranger district western yellow-pine trees up to 125 or 150 years old (the black-jack period) are rarely attacked by western red-rot, for the reasons previously given, while trees over 200 years old show a much higher percentage of rot than the younger trees (black jack). Any system of cutting that will take out most of the older trees (yellow pine) and many of the larger black jacks, as well as all suppressed trees, will do much to rid the future forest of this serious heart-rot. It also follows that a short rotation will be better for the future health of the forest so far as heart-rots are concerned. It is a fundamental fact that the older a tree is, the more liable it is to be attacked by heart-rotting fungi.

SUMMARY.

(1) A varying percentage of western yellow pines in Arizona and New Mexico is affected by a serious heart-rot called in this bulletin western red-rot.

(2) Western red-rot has three stages in its development: (*a*) An initial stage, in which the affected heartwood is firm but shows reddish to dark-brown discolored areas; (*b*) an intermediate stage, in which the diseased heartwood is whitish or gray in color and more or less delignified; (*c*) a final stage, in which much of the heartwood has disappeared, owing to the absorption of the delignified portions, while the wood particles left are brittle and crumble easily when handled.

(3) Western red-rot attacks both the sapwood and the heartwood of dead branches on living trees. It then travels down the dead branches into the heartwood of the living tree.

(4) No constant external signs were found which would absolutely determine whether or not a given living yellow-pine tree was attacked by western red-rot. However, trees growing on very thin soil on steep south or east slopes where growth conditions are very poor have a higher percentage of this rot than yellow pines situated where the growth conditions are good.

(5) Of the 1,815 black jacks examined for western red-rot, only 29, or 1.59 per cent, had this rot, while out of 563 yellow pines examined, 77, or 13.6 per cent, were attacked by this rot.

(6) So far as heart-rots are concerned a short rotation is better for the future health of the forest than a long one.

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